They are, moreover, being issued in such numbers, under the present demand for popular education, that their very likeness to one another is fatiguing. They require also in their construction the rare faculty, whether intuitive or gained by long experience, of insight into a student's probable difficulties; for it seems desirable that they should rather aim at being employed as condensors and systematisers of knowledge already acquired generally from the study of larger and more diffuse treatises, than as independent works. It is in this respect that useful practical knowledge differs from "cram"; a distinction very real, though more difficult to define than to understand. The concentrated food offered by such compilations is less easy of digestion, and more readily expelled from the mental economy, than that which is more gradually administered and more completely assimilated.

The writer of the present manual has, for instance, only seventy pages to devote to Sound, one hundred and eighteen to Light, and ninety-one to Heat, exclusive of the Appendix. But it is remarkable how much he succeeds in compressing within these very restricted limits. The illustrative experiments are, as a rule, simple and well chosen, though occasionally trite, and even of doubtful accuracy; as is seen in the drawing of the periodic curve of a musical sound at p. 40, and that of dispersion of light on p. 135. On the other hand, the use of a long spiral steel spring to illustrate waves of compression and rarefaction, the description of the effects of Temperature on Sound-waves, and the chapters on Interference, Diffraction, and Polarisation of Light, especially in its Circular and Rotatory forms, are ingenious and easy to comprehend.

A few simple numerical examples are given of each important law, with their solutions, and the mode of working out; a method which probably tends more than any other to fix essential points on the memory of the student. W. H. STONE

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*]

Postulates and Axioms

A STRONG committee, appointed, or rather re-appointed, for the purpose, reported last year to the British Association upon the Syllabus drawn up by the Association for the Improvement of Geometrical Teaching. I have only just seen a copy of the report, and I wish to point out that it incidentally touches in a misleading fashion upon a matter which, though primarily of only historical interest, is really of theoretical importance too, if not (in the strictest sense) for the special purpose of the committee; I mean upon the different ways of distributing the fundamental assumptions under the two heads of postulate and axiom.

Let us stop for a moment at the historical point of view. It is well known that the received text of Euclid, which we may consider represented by David Gregory's edition (Oxford, 1703), misplaces the assumption about right angles, the assumption at the base of the theory of parallels, and the assumption that two straight lines do not inclose a space. That is to say, whereas in the correct text these are the 4th, 5th, and 6th postulates, the received text makes them the 10th, 11th, and 12th common notions, or, as we usually say, axioms.

Now, when the report speaks of Euclid in this connection, it means something nearly identical with the received text. Not quite, however; for, though the language is not clear in all respects, it clearly says thus much, that Euclid divided the axioms into general and specially geometrical. But this is not the case in either text; for in both texts the first seven common notions are general, the 8th geometrical, and the 9th general again, nor is the 8th distinguished from the rest by its grammatical form. But whether you follow the received text or depart from both, it is unhistorical to affirm of Euclid what is not true of the correct text.

Let us now consider the theoretical significance of the two distributions. The case is thus stated by De Morgan, under *Eucleides*, in Smith's "Dictionary of Greek and Roman Biography," p. 66b:—"The intention of Euclid seems to have been to distinguish between that which his reader must grant, or seek another system, whatever may be his opinion as to the propriety of the assumption, and that which there is no question everyone will grant. The modern editor merely distinguishes the assumed *problem* (or construction) from the assumed *theorem*." This latter distinction is at least as old as Proculus; but to De Morgan it is Euclid's, at least as concerns right angles and parallels, that "seems most reasonable; for it is certain," he continues, "that the first two assumptions can have no claim to rank among common notions or to be placed in the same list with 'the whole is greater than its part.'" We need not pursue the modern editor's distinction further; but Euclid's acquires a more definite significance in relation to those generalised conceptions of space which, since De Morgan wrote these words, have almost passed into popular science. This in its generality is a difficult subject, but for the present purpose it is enough to regard plane geometry as a particular case of the geometry of points and lines on a given surface.

In this view the postulates specify the attributes of the plane which make plane geometry what it is. Thus the first three, whatever else they do, provide that the power of drawing diagrams shall not be restricted by boundaries, and the fourth, "all right angles are equal," affirms that a complete rotation is the same in quantity at all points; thereby the first three exclude surfaces having such a singular locus as a cuspidal line, and the fourth excludes surfaces having such a point as the vertex of a cone. Again the fifth excludes anticlastic surfaces, and the sixth synclastic ones and any which, like the common cylinder, returns into itself. Nothing remains but the plane and such developable surfaces as the parabolic cylinder to which *mutatis mutandis* everything in plane geometry will equally apply.

The axioms, on the contrary, specify no property of any class of surfaces. This is crucially instanced in the one axiom (the 8th, that things congruent are equal) which does concern figures traced on surfaces of only a limited class. For this axiom merely says that if things coincide they are equal, not that figures in different places may be brought to coincide.

The question may be asked whether this last assumption ought not to be premised somewhere; that is, whether the method of superposition ought not to have been vindicated by expressly assuming that any plane figure may be laid down on any plane so as to coincide with a portion of it. The omission is an extremely curious fact—in Euclid, I mean, for it is not at all remarkable in his successors. On the one hand, express statement is superfluous in the sense that the assumption is implied in the last two postulates; for the fifth affirms that the "measure of curvature" of the plane is not negative, and the sixth that it is not positive; between them it is naught, and therefore constant; but this is the condition of superposableness. On the other hand, express statement is indispensable in the sense that the student cannot do without it, because the theory of measure of curvature does not belong to elementary geometry.

The fact is that Euclid has drawn the line with what is really remarkable accuracy, but is only seen to be so in virtue of principles not discerned, I believe, by any one before Gauss. Whatever may be the explanation of this phenomenon, to ignore it in speaking of Euclid's postulates and Euclid's axioms is to depart from history where adherence to history would be instructive in theory too.

It is of course another question whether this distinction of Euclid's ought to be preserved in books intended to supersede Euclid. C. J. MONRO

Hadley, Barnet

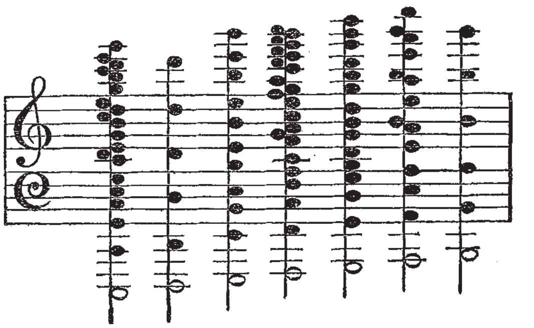
Just Intonation

THAT Mr. Chappell misunderstands me is due partly to his confounding vibration numbers with their ratios. Thus $\frac{27}{16}$ is the vibration number of the supertonic, where $\frac{3}{2}$ is that of the tonic; while 524288 is not the vibration number of any musical sound, though the ratio $524288 : 531441 = 2^{19} : 3^{12}$ expresses an interval that may be picked out fourteen times in each octave of Mr. Colin Brown's keyboard. A still more complex interval $2^{22} : 3^{14}$ is found seven times in each octave.

I have followed Mr. Chappell's advice and purchased his sixpenny pamphlet, and having read it with the care it deserves, I can only say I dissent from a great part of it, especially where

harmonics and the scale are treated of, and I am not surprised that its author cannot understand the numerical basis of Colin Brown's Just Intonation Harmonium.

The strict harmonic chords of the seven notes of the scale, including only sounds in the scale of C, and excluding all approximations, are these :—



Here it will be observed that all the tones of the scale are harmonics of F and of that note only (a circumstance first pointed out by Colin Brown). I do not admit that F and A are notes *interposed* in the scale of C. A. R. CLARKE

Ordnance Survey Office, Southampton, February 8

Protective Mimicry among Bats

I HAVE read with much interest the remarks of Dr. S. Archer in NATURE, vol. xv. p. 313, on the habits of *Rynchonycteris naso*, Wied. (= *Proboscidea saxatilis et rivalis*, Spix.), as they quite agree with notes on the same species made by me when travelling some years ago in British Guiana.

This is not, however, the first published notice of protective mimicry among bats. In my "Monograph of the Asiatic Chiroptera" (1876), I have referred to the peculiar markings of the wing and interfemoral membranes in *Kerivoula picta*, *Vespertilio formosus*, and *V. Welwitschii*, which are coloured on the same plan although these species are related in no other respects, and have stated that I believe these markings to be the result of "protective mimicry." Of one of the two first-named species, Mr. Swinhoe remarks :—" A species of *Kerivoula* allied to *K. picta* and *K. formosa*, was brought to me by a native. The body of this bat was of an orange brown ; but the wings were painted with orange-yellow and black. It was caught, suspended head downwards, on a cluster of the round fruit of the Longan-tree (*Nephelium longanum*). Now this tree is an evergreen ; and all the year through some portion of its foliage is undergoing decay, the particular leaves being, in such a stage, partially orange and black. This bat can, therefore, at all seasons, suspend from its branches, and elude its enemies by its resemblance to the leaf of the tree. It was in August when this specimen was brought to me. It had at that season found the fruit ripe and reddish-yellow, and had tried to escape observation in the semblance of its own tints to those of the fruit." [1]

A familiar instance of what appears to be "protective mimicry" occurs in the species of the genus *Pteropus* (Flying-foxes of European residents in India). These, the largest of all bats, measuring, on an average, nearly one foot in length with an expanse of wing of from four to five feet, are, from their large size, very conspicuous objects even when the wings are closed, and easily seen from the ground when hanging from lofty trees. With very few exceptions these bats have the fur of the back of the head and of the nape of the neck and shoulders of a more or less bright reddish or bright buff colour, contrasting strongly with the dark brown or black fur of the back. At first sight it might appear that this remarkable contrast of colours would render the animal more conspicuous to passing enemies, and consequently more subject to their attacks when hanging in a semi-torpid condition. But any one who has seen a colony of these bats suspended from the branches of a banyan tree, or from a silk cotton tree (*Eriodendron orientale*), must have been struck with their resemblance to large ripe fruits, and this is especially noticeable when they hang in clusters from the leaf-stalks of the cocoa-nut palm, where they may be easily mistaken for a bunch of ripe cocoa-nuts. Hanging close together, each with his head bent forwards on the chest, his body wrapped up in the ample folds of the large wings, and the back turned outwards, the brightly coloured head and neck is presented to view, and resembles the extremity of a ripe cocoa-nut, with which this animal also closely corresponds in size.[1]

[1] *Proc. Zool. Soc.*, 1862, p. 357.

The much smaller species of *Cynopterus* and *Macroglossus*, which feed on the fruit of guavas, plantains, and mangoes, resemble these fruits closely in the yellow colour of their fur and in their size, so that it is very difficult to detect one of these bats when suspended among the leaves of any of these trees.

The resemblances, however, between these frugivorous bats and the fruits of the trees on which they roost, may be accidental, and, in the present state of our knowledge, we would scarcely be justified in setting them down as the result of "protective mimicry," though there can be little doubt that, to whatever cause due, they aid in concealing these animals from the attacks of enemies.

I could adduce other instances of what appear to me to be cases of "protective mimicry" among bats, but my letter has already much exceeded the limits intended by me when I commenced it, and I must reserve my remarks on the peculiar position of *Rynchonycteris naso* when resting on a perpendicular plane surface for another communication. G. E. DOBSON

Sense of Hearing in Birds and Insects

IN respect to "The Sense of Hearing in Birds," the habit of pattering with the feet while seeking food, which is common to many worm-eating birds, seems to preclude the idea that such birds at least depend to any great extent upon their powers of hearing. Gulls frequently tread or patter with their feet while seeking food. The object being clearly to discover, from some slight movement, the whereabouts of their hidden prey. Plovers, doubtless with the same object, vibrate one foot rapidly with tremulous motion on the ground. Now the plover is essentially a worm-catching bird, more so even, probably, than the thrush. Light-footed, active yet stealthy in its movements, quick-sighted, and certainly quick of hearing, the plover, when feeding, runs a little way, like the thrush, then stops, with head erect, looking intently ; listening it might well be thought *but for the tremulous motion of its foot.* The plover, at such time, trusts without doubt to sight and not to its sense of hearing.

It is true that the thrush has not this trick of pattering with the foot. It is true also that it has, while seeking food, very much the look of listening attentively. The largeness of its eye and comparatively small development of its ear incline me, however, to believe with Mr. McLachlan (NATURE, vol. xv. p. 254), that the thrush also depends when feeding more on its power of sight than on its sense of hearing. C. J. A. MEYER

THE ATMOSPHERE OF THE ROCKY MOUNTAINS [2]

ANYONE who observes with a large telescope soon becomes aware of the great obstacle atmospheric undulation offers to the pursuit of astronomy, particularly in the application of photography and the spectroscope. During two years when I photographed the moon on every moonlight night at my observatory,[3] there were only three occasions on which the air was still enough to give good results, and even then there was unsteadiness. Out of 1,500 lunar negatives, only one or two were really fine pictures. A letter which the late Mr. Bond wrote to me states that in seventeen years he had never met with a perfectly faultless night at the Cambridge Observatory.

Such facts naturally cause astronomers to consider whether it is not possible to diminish atmospheric disturbances, and have led to the celebrated expeditions of Prof. Piazzi Smyth to the Peak of Teneriffe, and Mr. Lassell to Malta. Theoretically it would seem that the only complete solution is to ascend high mountain ranges or isolated peaks, and leave as much as possible of the air below the telescope.

Having had occasion during the months of August and September, 1876, to go on a hunting trip with two distinguished officers of the United States Army into the Rocky Mountains

[1] In a note to Sir James Emmerson Tennent's "Ceylon." Mr. Thwaites remarks :—" These bats (*Pteropus medius*) take possession during the day of particular trees, upon which they hang like so much ripe fruit."

[2] "Astronomical Observations on the Atmosphere of the Rocky Mountains, made at Elevations of from 4,500 to 11,000 feet, in Utah, Wyoming Territory and Colorado." By Henry Draper, M.D., Professor of Analytical Chemistry and Physiology in the University of New York. Communicated by the author.

[3] Prof. Henry Draper's observatory is at Hastings-on-Hudson, near New York ; latitude 40° 59′ 25″, longitude 73° 52′ 25″ ; elevation above the sea, 22 feet.